useful to see what common practices can be gathered from Semitic and British traditions. We have common to both:—

(1) Worship in high places.
(2) Setting up of stones.
(3) Sacrifices with blood poured on the altar.
(4) Fire worship of Baal or Bel.
(5) Human beings passing through the fire.

The question arises, then, were not the circle builders Semites antedating the Aryans?

The Dolmen Builders.

Another matter of great interest is connected with the erection of dolmens in imitation of the caves first used for Semitic worship. The most philosophical study of this question I have seen[1] certainly suggests that much light may be expected from this source.

NORMAN LOCKYER.

THE SKELETON OF BRONTOSAURUS AND SKULL OF MOROSAURUS.

THE exploration of the American Jurassic by Cope and Marsh for remains of the Sauropoda practically began on an extended scale in 1877. It has been continued by these pioneers and their successors with some interruptions to the present time.

During this period a number of more or less complete skeletons have been found. The first was that of *Camarasaurus supremus*, a sauropod closely related to the Morosaurus of Marsh, found in the Jurassic of Colorado in 1877, and partially described by Cope. It was restored life-size by Ryder on large sheets of linen and exhibited, but never published. The skeleton is now being prepared for mounting in the American Museum of Natural History. The most complete skeleton known of Brontosaurus is the type of *B. excelsus*, Marsh, which was found in the Como Bluffs of Wyoming in 1879, and made the basis of Marsh's restoration of 1883, the first published. This beautiful specimen was unfortunately taken out before the method of removal from the matrix was as effective as it is now. It is, however, capable of being mounted, and will undoubtedly some day be one of the great ornaments of the Yale University Museum, in which it is preserved. In 1897 the American Museum party found the entire hind portion of the skeleton of a Diplodocus also in the rich region of the Como Bluffs. Two years later another skeleton of a Diplodocus, the best yet discovered, was secured by the Carnegie Museum expedition, and forms the chief basis of the great cast recently presented to the British Museum. In 1901 the Field Columbian Museum, of Chicago, secured another fine sauropod skeleton, the basis of the restoration by Dr. E. S. Riggs. It is termed Apatosaurus, a name which Dr. Riggs thinks preoccupies Brontosaurus.

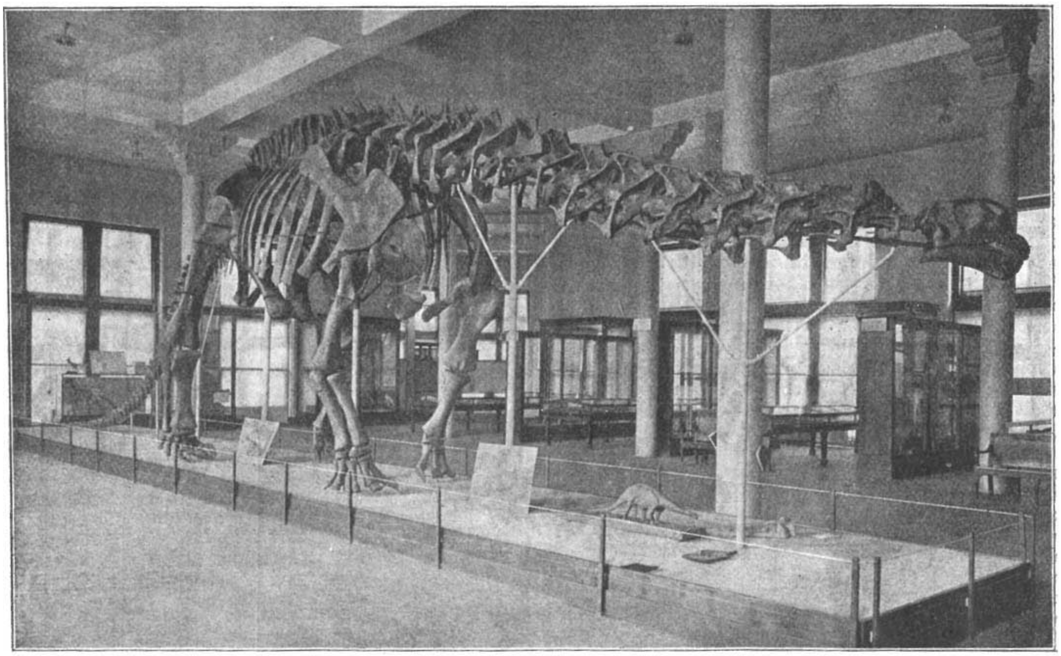

FIG. 1.—Skeleton of the *Brontosaurus excelsus* in the American Museum of Natural History, New York.

In 1897 the American Museum expedition discovered the skeleton of the Brontosaurus or Apatosaurus represented in the accompanying photograph. It enjoys the distinction of being the first of the Sauropoda to be mounted from the original materials.

The field and museum work on this skeleton occupied the American Museum staff more or less continuously from 1897 to the spring of 1905. In 1898 and 1899 the excavation was carried on, and a little more than two-thirds of the entire skeleton was recovered. In the following year a few more vertebræ were found. The special features are the very large size of the animal, the absence of crushing of the bones, and the completeness of the ribs. The original parts are supplemented by bones and casts or models from other individuals. The chief parts entirely missing are the skull, which was restored partly from an imperfect skull of Brontosaurus, partly from that of the Morosaurus described below, the three anterior cervical vertebræ, the forearms of both sides from the shoulder down, which were restored from the Yale University specimen, the upper portions of the sacrum, the hind-limb of one side, and the terminal portion of the tail. The hind-limb and the tail were completed from other individuals in the American Museum of Natural History.

The mounting represents the prolonged work of very difficult restoration and the solution of a number of quite new mechanical problems for the support of the immense weight of the fossil skeleton without making the iron and steel work too obtrusive. For this the head preparator, Mr. Adam Hermann, deserves chief credit. A number of new anatomical problems arose, especially as to the position and angulation of the fore-limbs. In this connection the writer's assistants, Messrs. Matthew and Granger, made a complete restoration of the muscles of the shoulder girdle and of the neck on the basis of dissections of the alligator and lizard. As a result, two important modifications of previous restorations have been made, first, the scapula is considerably more depressed below the level of the back than in previous restorations, thus allowing space for the cartilages between the ribs and coracoid, second, the elbows are considerably everted.

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[1] "The Builders and the Antiquity of our Cornish Dolmens," by Rev. D. Gath Whitley (*Journal R.I. Cornwall*, No. 1.).

In all previous restorations the manus is represented as provided with a nearly complete series of terminal claws like those of the pes, which lacks the terminal claw only on two digits. Comparison of ten specimens of Sauropoda in various museums has convinced the writer that, *according to present evidence,* in Diplodocus and Brontosaurus there is but one claw in the manus, and that a small one, on the pollex. The arching and elevation of the backbone also come in for considerable modification. Although, as previously supposed by the writer on other grounds, the sacrum was the centre of power and of motion in this great animal, as a result of the depression of the scapula the posterior portion of the neck and middle portion of the back were elevated, and the highest vertebra of the back is not necessarily the spine of the sacrum. Another characteristic of all Sauropoda is the elongation of the neck and the extreme abbreviation of the back, which now in several forms is found to be composed of from ten to eleven vertebræ only. Brontosaurus seems to differ from Diplodocus in the relative abbreviation of length as a whole correlated with the greater massiveness of the skeleton, but especially in the abbreviation of the tail.

	Cervicals	Dorso-lumbars	Sacrals	Caudals
Brontosaurus ...	13 est. ...	10 ...	5–6 ...	49 ± est.
Diplodocus ...	15 ...	11 ...	4–5 ...	35–40

In three specimens of Diplodocus evidence has been found of the consolidation of certain vertebræ of the tail (caudals, 17–18 and 19–21) at the point where they reach the ground. From this it has been inferred that the tail was used partly as a bracing or supporting organ when the anterior half of the body was elevated. There is no evidence of such consolidation in Brontosaurus, and the tail was relatively much shorter. Another difference is that in the tail of Diplodocus the vertebral spines are very lofty, and the transverse processes laterally compressed, indicating that this organ was partly used for propulsion in the water. These characters are much less strongly developed in the massive limbed Brontosaurus.

In this connection we may mention two partly antagonistic theories of the habits of this animal. First, the aquatic theory suggested by Owen in his original study of Cetiosaurus on account of the shape of the caudal vertebræ, and partly supported by Cope on the ground of the extreme lightness of the dorsal vertebræ; this has been more recently supported by Matthew and Gidley on the ground that the limbs were incapable of progression upon land, and were very much more strongly flexed than in any of the restorations of the animal which have been published. The amphibious theory has been partly developed by Cope and the present writer, namely, that the animals spent a considerable part of their life in the water, but were also capable of progression, and even of feeding, upon land; that during the reproductive and hatching period they spent a considerable time on land guarding their nests. A similar theory was advocated by Hatcher in his memoir on Diplodocus.

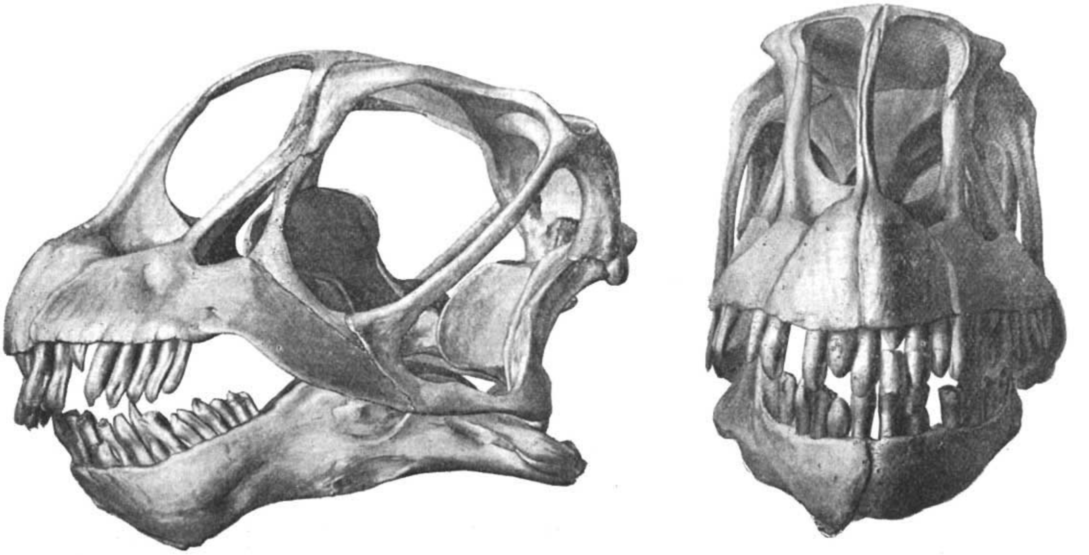

FIG. 2.—Skull of the *Morosaurus grandis*, 1/7 Natural Size.

The size of the Brontosaurus has been very generally overestimated. The chief measurements of the present skeleton as mounted are:—

	Feet	Inches
Length over all from head to tip of tail ...	66	8
Length of vertebral column	64	4
Length of neck...	16	10
Length of tail	31	4
Length of longest rib...	6	9
Length of hind-limb, including foot ...	10	7
Length of fore-limb, including foot... ...	8	6
Depth of body from lower end of pubis to top of posterior dorsal spine	8	7
Length of head as restored	2	4
Estimated weight of animal when alive ...	38 tons	

As above noted, the long-limbed Diplodocus attained a greater length; the specimen recently presented to the British Museum is 84 feet long. The little known Barosaurus, related to Diplodocus, was of still larger size, and the Brachiosaurus of Riggs had a much greater length of limb, but we have no means of ascertaining its length over all.

It is interesting to compare these measurements with those of a fully grown "sulphur bottom" whale, carefully measured by Mr. F. A. Lucas, and reproduced at the St. Louis Exposition. This animal, a male, measured 74 feet 8 inches from the notch of the flukes to the tip of the nose. The approximate weight of the bones was 17,920 pounds. The entire animal was estimated at not much less than 63 tons.

Our estimate of the weight of Brontosaurus is based on a model by Mr. Charles R. Knight on a one-sixteenth scale, founded upon the actual measurements of the present skeleton. As carefully estimated by Mr. W. K. Gregory and Prof. William Hallock, of the physical department of Columbia University, the Brontosaurus displaced $34\frac{1}{4}$ tons of water. If the animal was slightly heavier than the water which it displaced, say 10 per cent., it would weigh 38 tons. Prof. Hallock thinks that an estimate of from 35 tons to 40 tons would be very near the truth, even allowing for errors of restoration.

Skull of Morosaurus.

Before the British Association at the Cambridge meeting the remarkable deposit of dinosaur remains known as the "Bone Cabin Quarry" was described. The quarry, which lies about nine miles north of the Como Bluffs, west of the Rockies in south-central Wyoming, is believed to represent a delta or mud and sand bar formation, in which were accumulated more or less complete remains of all the dinosaurs of the period.

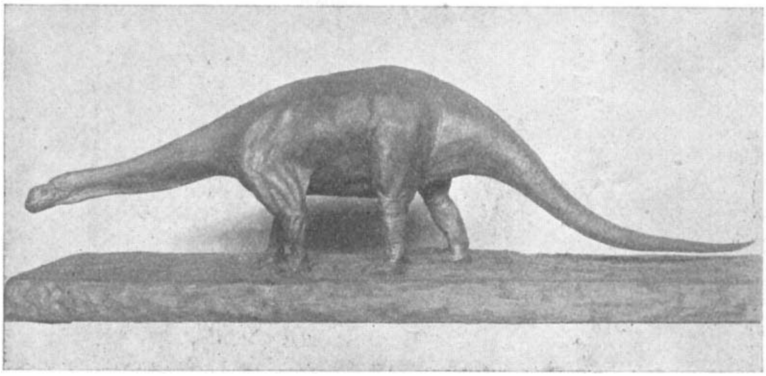

FIG. 3.—Model of the Brontosaurus, by Charles R. Knight. Scale of Photo., 1/109. Scale of Model, 308 mm. high, 1/16 Natural Size.

One of the most rare and welcome products of this quarry in the continuous workings which began in 1897 and were recently completed have been the series of skulls, because the skull is the rarest and most fragmentary part of any of the Jurassic dinosaurs. They include one complete and two incomplete skulls of Diplodocus, two complete skulls of the carnivorous Allosaurus, one of Ornitholestes, the supposed bird-catching dinosaur, one of Laosaurus, a primitive iguanodont, one complete skull and portions of two other skulls of Morosaurus. This last is herewith described and illustrated for the first time. It was found at the end of a series of cervical vertebræ by Dr. W. D. Matthew in an extremely crushed condition, and its restoration required great skill and care.

Hitherto our knowledge of the skull of the Sauropoda has been limited to the single complete skull of Diplodocus and to the posterior portion of the cranium of one specimen of Morosaurus, both described by Marsh. These new materials, therefore, greatly expand our knowledge.

The most important point brought out is that all three skulls exhibit a well defined tubular opening on top of the skull at the junction of the parietals and paroccipitals. This foramen is smoothly lined with bone, and leads directly down into the cerebral cavity. It is thus probable that it lodged a large pineal eye, an organ the existence of which was left problematical by Marsh, as shown in the following passage :—

"There is no true pineal foramen, but in the skull here figured (Plate ii.) there is the small unossified tract mentioned above. In one specimen of Morosaurus a similar opening has been observed, but in other Sauropoda the parietal bones, even if thin, are complete." In Marsh's drawing the parietal opening is indicated rather as a fontanelle than as a foramen. While this opening is observed in the form of a bony tube in three skulls, it is of course possible that it was not invariably present in the Sauropoda, and that in some forms the foramen was partially or completely roofed over.

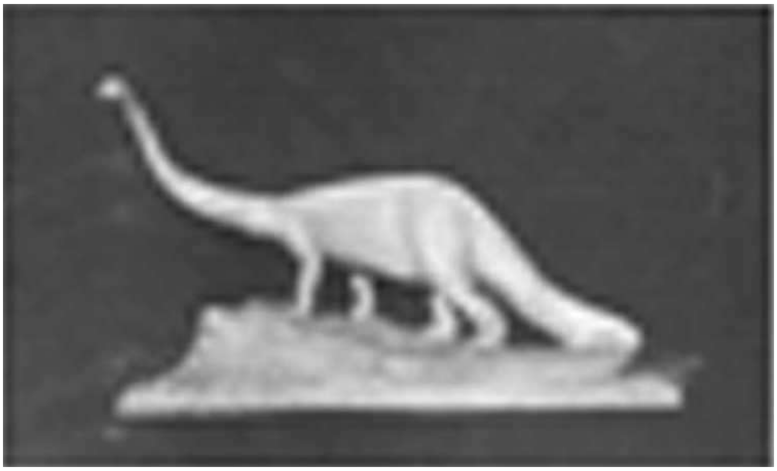

FIG. 4.—Model of the Diplodocus, by Charles R. Knight. Scale of Photo., 1/105. Scale of Model, 826 mm. long, 1/16 Natural Size.

It will be recalled that the skull of Diplodocus has a long snout or antorbital extension supporting a series of slender, pencil-like teeth. The skull of Morosaurus differs widely from this type, first in the highly convex forehead or antorbital region, which is undoubtedly correlated with the presence of the great spoon-shaped cropping teeth, which were comparatively powerful and presented considerable resistance. Above, there are four premaxillary and eight maxillary teeth, decreasing in size as they extend toward the back of the jaw. From twelve to thirteen teeth are preserved in the mandible. The deep, massive proportions of the premaxillaries, maxillaries, and mandibular rami are also mechanically correlated with the insertion and powerful functions of these large teeth. It is evident, however, that as in Diplodocus the animal had no power of masticating its food, and that these anterior teeth served simply for prehensile purposes.

The anterior narial or respiratory openings are very large, facing forward rather than more directly upward, as in Diplodocus, while the openings in front of the orbits are correspondingly reduced. As restored in this specimen, the orbits are of enormous size, but considerable restoration was necessary in the bone surrounding this region, so that the contours of the orbits cannot be certainly ascertained. In the superior aspect of the skull it is evident that the frontal and nasal bones were much longer than in Diplodocus. It is noteworthy that the occiput or back part of the skull has practically the same composition as in the carnivorous Dinosaurs, namely, the parietals hardly enter at all into the top of the cranial roof except to bound the parietal or pineal foramen at the sides; this foramen, which is absent in the carnivorous dinosaurs, is bounded posteriorly by the supraoccipitals. The squamosals form the infralateral portions of the occiput. These resemblances tend, so far as they are of value, to sustain Prof. Seeley's view that the Sauropoda and Theropoda, or carnivorous dinosaurs, are more nearly related to each other (Saurischia, Seeley) than either are to the Predentata (Ornithischia, Seeley); in fact, it is possible to derive the sauropod type from a primitive quadrupedal theropod type, but not to derive either from an iguanodont type.

HENRY FAIRFIELD OSBORN.

American Museum of Natural History, October 5, 1905.